scanty, and "lack of food as well as the absence of light was one of the factors concerned in the diminution of size and in the slenderness of blind cave animals as compared with their lucicolous allies."

The effect of total darkness upon animals is twofold. Firstly, colour is either entirely or partially bleached, and, secondly, the sense of sight is lost. Eyesight may be lost in various ways. Either the optic lobes and nerves may atrophy, while the retina, pigment, and lens remain more or less persistent; or the optic lobes and nerves may persist, while the retina and eye-facets atrophy; or, again, the whole of the optic apparatus may atrophy. Examples of all these cases are given in the important chapter which is devoted to a description of the anatomy of the brain and eyes of certain blind Arthropods, and illustrated by numerous drawings of sections through various regions of the head.

It is argued that this atrophy must be comparatively sudden and wholesale, because no series of individuals has been found with the optic lobes or nerves in different stages of disappearance. Transitional forms have been observed with eyes with a varying number of crystalline lenses, as in the case of *Chthonius*; those individuals which live near the mouth of the cave have better developed eyes than those which live far in. And surely, on further examination, more transitional forms will be discovered, as animals must be continually getting into the caves from the outside; their descendants becoming gradually adapted for cave life, until they finally reach the degree of modification of the present older occupants.

As the sense of sight diminishes, it is compensated by an increase of the delicacy of other senses. The tactile and olfactory senses are rendered more sensitive, the appendages become much more slender, and the blind form is altogether more timid and cautious than its eyed allies, as has been particularly noticed in the blind crayfish.

The last part of this memoir deals with what is of most general interest to the biologist, viz. the bearing of these facts upon the theories of evolution. The author states that here the term "natural selection" expresses the result of a series of causes rather than any one cause in itself. The most important of these causes are: the *change of environment*, from light to partial or total darkness, involving diminution of food, the disuse and loss of certain organs, with compensation as has been mentioned above; *adaptation*, enabling the more plastic forms to survive and perpetuate the stock; *heredity*, which operates to secure the future permanence of the newly originated forms—the longer it acts, the earlier will the inherited characters appear in the development of the animal; and, lastly, *isolation*, which, after adaptation and heredity have established the typical characters, prevents intercrossing with out-door forms, and thus insures the permanence of these characters.

The author adduces facts which seem to prove that the organic adaptations to a life in darkness may have been induced after but a few generations, perhaps one or two only, resulting in the comparatively rapid evolution of cave species. If that be the case, then, there is no reason why they should not be produced artificially, but at present no experiments have been made to prove the mutual convertibility of cave species and their lucicolous allies. If a cave species could be made to revert to an epigean form by keeping it for a number of generations in a gradually increasing amount of light; and if, on the other hand, a lucicolous species could be changed into a cave form by a converse process, the theory of occasional rapid evolution due to sudden changes in the environment would receive its final proof.

Mr. Packard draws attention to the interesting parallel between the life of the abysses of oceans and lakes and that of caves. In both cases vegetable life is almost absent, and a large proportion of the animal forms have become similarly modified with regard to the degeneration of the optic organs and corresponding development of other organs as compensation. But while caves have only been populated comparatively recently, the ocean abysses have had inhabitants for a very much longer time, and consequently these have had time to become much more highly specialized than the inhabitants of caves.

This most valuable contribution terminates with a bibliography containing the titles of previous publications on the subject, and we must not omit to mention that in a separate chapter a list is given of the known non-cavernicolous blind animals. As far as the higher classes are concerned, this list contains about the same number of species as the one of the blind cave-dwelling forms.

R. T. G.

LINEAR DIFFERENTIAL EQUATIONS.

A Treatise on Linear Differential Equations. By Thomas Craig, Ph.D. Vol. I. Equations with Uniform Coefficients. (New York: John Wiley and Sons, 1889.)

TREATISES on this subject have been somewhat numerous of late. We recently noticed in these columns an excellent, but fairly elementary work, "On Ordinary and Partial Differential Equations," by Prof. Woolsey Johnson. The student who wishes to enter on the profitable perusal of the book before us must be well versed in all the ordinary modes of procedure,[1] and then he will find that Dr. Craig is well qualified to lead him through the intricate windings of this difficult branch of mathematics. The advanced student will find the author's analyses of use to him whilst reading the various original memoirs here introduced to him, for the first time, in English. Some may remember that Mr. Forsyth, in his classical treatise, omitted the investigations of Fuchs, the recent researches of Hermite and Halphen, contented himself with a slight sketch of Jacobi's method for partial differential equations, and did not at all touch upon the methods of Cauchy, Lie, and Mayer. The consideration of these matters he reserved for a future volume.

The theory of the subject before us, *i.e.* of linear differential equations, almost owes its origin, in Dr. Craig's opinion, to two memoirs by Fuchs, published in vols. lxvi. and lxviii. of *Crelle's Journal* (1866, 1868):—

"Previous to this the only class of linear differential equations for which a general method of integration was known, was the class of equations with constant coefficients, including, of course, Legendre's well-known equation, which is immediately transformable into one with

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[1] "The reader is of course supposed to be familiar with the ordinary elementary theory of differential equations" (p. 32).

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constant coefficients. After the appearance of Fuchs's second memoir, many mathematicians, particularly in France and Germany, including Fuchs himself, took up the subject, which, though still in its infancy, now possesses a very large literature."

As happens in such cases, these memoirs have to be dug out of journals and publications of learned Societies before the student can be put in possession of results obtained. It is for this labour of research, and then for the arrangement in due sequence of theorems, that the reader has to thank Dr. Craig.[1] Even in the first two chapters, where most of the results are old, the treatment is comparatively new, being founded upon papers by Laguerre (*Comptes rendus*, 1879), and upon memoirs, or works, by Briot and Bouquet and Jordan; reference is also made, in connection with a proof by Jordan, to a paper by Picard (*Bulletin des Sciences Math.*, 1888). Here we may note that the author reserves an account of the investigations of Laguerre, Halphen, and others, from a still higher point of view, to a subsequent volume.

This first instalment discusses principally Fuchs's type of equations, but accounts are given of the researches of Frobenius (chapters iv., viii.), Markoff, Heun, Riemann, and Humbert (chapter vi.), Thomé (chapter ix.), Halphen (chapter xii.), Forsyth's canonical form and associate equations, Brioschi, Lagrange's adjoint equation, Halphen's adjoint quantics and Appell's theorem (chapter xiii.), and Picard (chapter xiv.). An account, due to Jordan, is given of the application of the theory of substitutions to linear differential equations (chapter iii.). Many points are touched lightly here, a fuller development being held in reserve. A prominent feature is the reproduction (chapter vii) of a thesis by M. E. Goursat on equations of the second order satisfied by the hypergeometric series. This consists of two parts. The first part gives an application of Cauchy's theorem, and relations between Kummer's (24) integrals, an application to the complete elliptic integral of the first kind, and Schwarz's results. The second part discusses the transformations of the hypergeometric series, Tannery's theorem, and some other points, the article closing with a collection of 137 transformations due (apparently) to Kummer.

The pages bristle with references to original sources, so that, as we have already indicated, this treatise is an invaluable handy-book to what has been done in this field.

One more word: there is no collection of examples for solution on the Cambridge model, but the work is strictly on the lines of a French or German treatise.

The book itself is very elegantly turned out.

THE BACTERIA OF ASIATIC CHOLERA.

The Bacteria of Asiatic Cholera. By E. Klein, M.D (London: Macmillan and Co., 1889.)

SO masterly and complete was the account which Koch gave in 1884 of the comma-bacillus, which he held to be the virus of cholera, that but little, if anything, has been added to our knowledge of its mode of growth, of its reaction to dyes, or of its life-history. As might be expected, the assiduity of many observers, now it has been directed to the subject, has led to the discovery of many other bacilli, which may be described as comma-shaped. But, so far, no bacteriologist, who has had his observations corroborated by other observers, has proved that any of them are indistinguishable in all their physical characters, whether in appearance, in reaction to dyes, or in their mode of growth, &c., from the choleraic bacillus. So far as is known, animals are not susceptible to cholera. If Asiatic cholera could be induced by inoculating with pure cultivations of choleraic comma-bacilli, then beyond a doubt they would be the *vera causa*, or, in other words, the contagium of cholera; but this step in Koch's argument was wanting, probably for the above-named reason, and is likely to remain so: the experimental inoculations of guinea-pigs which have taken place being by no means conclusive.

The present volume is a valuable and most trenchant criticism of every step of Koch's argument, and may be said to contain everything that can at present be said against Koch's theory, of which the author is the most active opponent.

The author commences with an account of the various comma-shaped bacilli which are at present known, and there are well-recognized characteristics which distinguish them from the first form, in all of them, except in those which depend upon solitary observations.

The following is the list of comma-shaped bacilli with the names of their discoverers:—

(1) Koch, in Asiatic cholera; $\frac{1}{2}$ to $\frac{2}{3}$ the length of tubercle bacilli, but thicker and curved. (2) Finkler and Prior, in cholera nostras; but Koch and Frank failed to demonstrate these in typical cases. They are thicker and longer than (1). In 10 per cent. gelatine, the growth is broad and conical, liquefying the gelatine more rapidly. (3) Lewis, in the fluid of the mouth, thicker than (1) Klein only twice has succeeded in growing them; every one else has failed. (4) Miller, in some cases of caries of the teeth, similar to (2). (5) Kuisl, in human fæces similar to (2). (6) Deneke, in stale cheeses. The growth on gelatine is similar, but they will not grow on potatoes. (7) Klein, in some cases of diarrhœa, especially in monkeys. They grow differetly in gelatine, and cause it to smell offensively. (8) Ermengen and others, in the intestines of guinea-pigs, pigs, rabbits, horses, &c., but they will not grow in 10 per cent. gelatine. (9) Lingard, two kinds in a case of noma, the smaller of which is said to have been very similar to the choleraic one. (10) Weibel, various forms in mucus, but their mode of growth is distinct. (11) Gamaleïa, in a fatal fowl disease, which was prevalent at Odessa. He did not distinguish them from (1). (12) Klein, in the intestines of a monkey with diarrhœa. The organisms were smaller, but the growth was similar to (1).

Klein lays great stress upon the difficulty there is in demonstrating the presence of the bacilli in the walls of the intestine in cases of cholera, and thinks that they are not present in the parts which are still alive, but only where the tissue has died; moreover they are absent from the blood.

The bacilli are most readily found in the mucous flakes; and in the presence of fæcal matter they are

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[1] For instance, he obtains certain forms in the same way that Fuchs obtained them, "if for no other reason than that of the desirability of developing the subject in historical order" (p. 64).

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